Studies on Protozoan and Helminth Parasites of Freshwater Fishes of Godavari Basin

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1. Introduction

Freshwater fish are not only a delightful addition to aquatic ecosystems but also serve as a valuable source of nutrition for human consumption Macadam, C. R., & Stockan, J. A. (2015). The nutritional composition of freshwater fish makes them an essential component of a balanced diet Prabu, E. et al.(2017), providing a rich source of proteins, essential fatty acids Tocher, D. R. (2010). Vitamins, and minerals Paul, B. N et al. (2018). The consumption of freshwater fish has been associated with numerous health benefits Chen, J., Jayachandran, M. (2022), making them a significant contributor to global food security Tacon, A. G et al. (2013).

Freshwater fish are renowned for their high protein content Chalamaiah, M (2012), which is crucial for the growth and repair of body tissues Sarojnalini, C et al. (2019). The proteins found in fish are considered of high biological value Malik, D. S (2020), meaning they contain all essential amino acids required by the human body Hou, Y (2015). Fish proteins are easily digestible and have been recognized for their role in supporting muscle development, immune function, and overall cellular health Lees, M. J. (2020). In fact, fish proteins are often considered superior to those derived from land animals due to their favorable amino acid Pelletier, N. (2018)

Freshwater fish are a natural source of various vitamins and minerals essential for maintaining good health Balami, S et al. (2019). Khalili Tilami et al. (2018). These include vitamin D, vitamin B12, iodine, selenium, and zinc Lall, S. P et al. (2021). Vitamin D is crucial for bone health and immune system function, while vitamin B12 is vital for nerve function and the formation of red blood cells Hei, A. (2020). Minerals such as iodine, selenium, and zinc play important roles in thyroid function, antioxidant defense, and immune support, respectively Green Gasco, Let al. (2018).

The increase in population worldwide has led to a growing demand for food, including a significant reliance on fish as a source of nutrition Béné, C. (2015). As the global population continues to rise, reaching over 7.9 billion people in 2023 according to estimates, the need for sustainable and nutritious food sources becomes increasingly crucial Lutz, W. (2023).

The Godavari Basin, one of the largest river basins in India, is a vital freshwater ecosystem supporting a rich diversity of aquatic life, including numerous species of fishes Khedkar, G. D et al. (2014). Within this dynamic aquatic environment, protozoan and helminth parasites play significant roles in shaping the health and ecology of freshwater fish populations El-Khayat, H. M et al. (2024). Understanding the dynamics of these parasites in the Godavari Basin is of paramount importance, not only for the conservation and management of aquatic resources but also for safeguarding public health in the region Nair, N. Vet al. (2023).

Studies focusing on protozoan and helminth parasites of freshwater fishes in the Godavari Basin have garnered increasing attention due to the basin's ecological significance and its importance for local communities reliant on fisheries resources Pink, R. M. (2016). The basin's

diverse array of habitats, ranging from pristine headwaters to anthropogenically impacted downstream reaches, provides a unique opportunity to investigate the diversity 25.Heino, J.(2022), distribution, and ecology of freshwater fish parasites across varying environmental gradients Blasco-Costa et al.(2013).

Protozoan parasites such as various species of Myxozoa, Microsporidia, and Apicomplexa Paladini, Get al. (2017), along with helminths including trematodes, cestodes, and nematodes, are known to infect freshwater fishes inhabiting the Godavari Basin Vankara, A et al. (2011). These parasites exhibit complex life cycles often involving intermediate hosts, which may include other fish species, thereby influencing both the structure and functioning of the basin's aquatic ecosystems Overstreet, R. M. (2021).

The investigation of protozoan and helminth parasites in the Godavari Basin necessitates a multidisciplinary approach, integrating aspects of parasitology, ecology, hydrology, and socio-economic factors KS, R. T. S. V. A., Bhat et al. (2016). Researchers aim to elucidate the factors driving parasite diversity and distribution, host-parasite interactions, and the influence of environmental stressors such as pollution, habitat modification, and climate change on parasite dynamics in the basin Brunner, F. S et al. (2016).

Furthermore, given the reliance of local communities on freshwater fish for sustenance and livelihoods, understanding the implications of fish parasites for public health is crucial Parker, M., Allen et al. (2012). Many freshwater fish parasites have the potential to infect humans through consumption of contaminated fish, posing risks to human health in communities along the Godavari Basin Panda, B. P., Mohanta et al. (2023).

2. Literature Review

Tomáš Scholz et al. have focused to highlights significant gaps in knowledge regarding parasites of freshwater fishes in North America. These gaps include species composition, host specificity, life cycles, and evolution, phylogeography, and host-parasite relationships. The neglect of this area of research can be attributed to factors such as lower economic importance, limited funding, and a shortage of trained researchers, with many shifting to other fields or marine habitats. Future research opportunities include investigating the impacts of climate change and exploring cryptic species diversity. However, a major challenge is the loss of experienced parasitologists, leading to a decline in expertise for identifying organisms and an incomplete understanding of ecosystem dynamics, particularly in the context of climate change, emerging diseases, and biodiversity loss Tomáš Scholz. 2014.

Aline A. Acosta et al. have proposed a survey of helminth parasites in freshwater fish. They collected and examined 405 fish, finding a total of 50 helminth parasite species. The nematodes Rondonia rondoni and Parasynodontisia petterae had the highest infection rates. They analyzed the parasite communities within fish species, noting Trachydoras paraguayensis had the most diverse community, while Pterygoplichthys ambrosettii had the richest. This richness was

attributed to the number of directly transmitted dactylogyrids. Overall, their study identified 38 new host records, significantly contributing to our understanding of helminth parasites in Neotropical fish Aline A. Acosta et al. 2020.

Muhammad Moosa Abro et al. have proposed pathogenic nematode was detected from buccal cavity and intestine of a fish, tire track eel,Mastacembelus armatus sampled from Indus River. The parasite was identified as member of genus Eustrongylides (larval stage) and was observed from some twelve individual hosts. The parasite is reported for the first time from present sampling locality. Their studied added locality extension of the pathogenic nematode from the Indus River Muhammad Moosa Abro et al, 2020.

Donald B. Jyrwa et al. proposed studies incorporate the spectrum, composition and diversity of the parasitic species in freshwater fishes in Meghalaya, Northeast India, with a view to identifying the species recovered by morphological criteria based on light microscopy. The collection sites included sixteen foci from eleven districts of Meghalaya for parasites occurring in the common food fishes (Cypriniformes, Channiformes, Silurformes, Symbranchiformes and Anguilliformes). The helminth parasite spectrum recovered from the various piscine host species in the study area comprised of a total of 19 taxa: 2 monogenean, 8 trematode (4 adult and 4 metacercarial stages), 12 cestode (11 adult and a metacestode stage), 6 nematode (3 adult and 3 larval stages) and a single acanthocephalan species (Donald B. Jyrwa et al. 2016) .

Mina Ziaratia et al. have proposed the incidence of zoonotic diseases can be reduced by properly processing fish and fish products, e.g. by thermal (heat/freezing) treatment. The prevalence of zoonotic agents in fishes varies seasonally and should be regularly monitored to evaluate the prevalence of pathogens in both wild and cultured fish populations. This review focuses on the fish zoonotic agents/diseases and their control and prevention (Mina Ziarati. 2022).

Salwa Mahmoud Abd-ELrahman et al. have proposed the early detection of parasites and the improve control of the major risk factors related to infection are among the main approaches for controlling infection. Limited information is available on fish parasites in Upper Egypt. The present study examined the prevalence of parasitic infection among 300 fish samples collected from different markets in Assiut Governorate, Upper Egypt, using a series of detection techniques, including microscopic, parasitological, histopathological and morphometric methods. Moreover, the associations of the demographic factors with the distribution of parasitic infection in Nile tilapia were also investigated (Salwa Mahmoud Abd-ELrahman et al.2023).

Taqdees Farooq et al. have detection Four different species of endoparasites were recovered from Schizothorax species which include Adenoscolex kashmirensis Mehra, 1930, Bothriocephalus acheilognathi Yamaguti, 1934, Echinorhynchus sp., Pomphorhynchus kashmirensis Kaw, 1941, belong to Phylum Platyhelminths and Phylum Acanthocephala. Prevalence and generation time were inversely proportional to each other. Prevalence and mean

abundance were highest at Qamarwari. Diversity was more at Tengpora. Cestodes including Adenoscolex kashmirensis and Bothriocephalus acheilognathi were more dominant than Pomphorhynchus kashmirensis and Echinorhynchus sp (Taqdees Farooq et al. 2016).

A checklist of the parasite species with short remarks for each is provided herein in Table 1.

Table 1. Displays comparative Studies

Parasite Type	Characteristic	Common Species	Prevalence (%)	Intensity (Mean)	Variation	Source
Nematodes	Long, cylindrical worms in digestive tract or body cavity	*Contracaecum, Camallanus*	40-60	2-4	Seasonal	Younis, A. E., et al. (2017)
Cestodes	Flat, ribbon-like worms in digestive tract.	*Diphyllobothrium, Bothriocephalus*	20-30	1-3	Seasonal	Kaur, H. (2014)
Trematodes	Flatworms with leaf-like appearance, in gills or digestive organs.	*Diplostomum, Heterophyidae*	15-25	1-2	Location-dependent	Maciel, P. O. et al.(2018)
Protozoa	Single-celled organisms affecting gills and skin.	*Ichthyophthirius, Cryptobia*	30-50	3-5	Highly variable	Vanhove et al. (2011)

We aim to investigate the diversity and prevalence of protozoans and helminths parasitic infecting freshwater fish species from the Godavari Basin (Nanded) - Maharashtra - India , focusing on key taxa including nematodes, cestodes, trematodes, protozoa, monogeneans. Our project framework involves comprehensive field sampling, laboratory analysis. Initially, we will design a systematic sampling strategy to collect fish specimens from various locations along the Godavari Basin, encompassing different habitats and fish species. Upon specimen collection, we will conduct thorough laboratory examinations, utilizing microscopy and molecular techniques for the isolation and identification of parasitic organisms inhabiting different anatomical regions of the fish, including gills, intestines, and skin. Through meticulous taxonomic identification and characterization, we will elucidate the species richness, prevalence, and abundance of each parasite group within the sampled fish populations. Subsequently, statistical analyses will be employed to assess potential correlations between parasite infection and fish species, size. By providing a comprehensive understanding of parasite diversity and dynamics in freshwater fish populations of the Godavari Basin, our research aims to contribute valuable insights for the management and conservation of this vital aquatic ecosystem

3. Objectives of the Research and Proposed Hypothesis: -

The objectives of the proposed study are as follows:

- To identify the types of protozoan and helminth parasites present in freshwater fishes of the Godavari Basin (Nanded).
- To determine how common these protozoan and helminth parasites are among different fish species of the Godavari Basin (Nanded).
- To characterize the morphological features of the identified protozoan and helminth parasites.
- To taxonomy of the identified protozoan and helminth parasites by taxonomic keys.
- To assess the impact of these parasites on the health and population dynamics of freshwater fishes of the Godavari Basin (Nanded).

4. Methodology:

❖ Materials:

1. Fishing and Sampling Equipment:

- Fishing nets, traps, or rods for capturing freshwater fish.
- Containers or buckets for holding captured fish specimens.

2. Laboratory Equipment:

- Microscopes (stereo and compound) with appropriate magnification.
- Dissection tools: scissors, forceps, needles, scalpels.
- Incubators or temperature-controlled chambers (if culturing parasites).
- PCR machine and gel electrophoresis equipment for molecular analysis.
- Refrigerators and freezers for sample storage.

3. Chemicals and Reagents:

- Fixatives (e.g., formalin) for preserving parasite specimens.
- Staining solutions (e.g., hematoxylin and eosin) for microscopy.
- PCR reagents: primers, DNA polymerase, dNTPs, buffers.
- Ethanol or other solvents for sample preservation.

4. Reference Materials:

- Taxonomic keys, guides, and atlases for identifying fish species and parasites.
- Scientific literature and online databases for parasite research.

5. Personal Protective Equipment (PPE):

- Gloves, goggles, lab coats for safety during fieldwork and lab procedures.

❖ Methods

1. Study Area

The study will conduct in located the Godavari Basin (Nanded)- MS- India. The Godavari Basin (Nanded) is an area freshwater which content for its diverse fish species.

2. Sample Collection:

Fish specimens were collected from different sampling sites along the Godavari Basin (Nanded). Sampling was carried out using fishing nets and traps. A variety of freshwater fish species were targeted, representing different ecological niches and habitats.

3. Fish Specimen Examination:

Each will collect fish specimen is carefully examine for the presence of protozoan and helminth parasites. External parasites, such as ectoparasitic worms were visually inspected on the skin, fins, and gills of the fish. Internal parasites, including endoparasites, were examined by dissecting the fish and inspecting various organs and tissues.

4. Parasite Isolation:

To isolate protozoan and helminth parasites, samples are collected from the infect fish. For ectoparasites, scraping or rinsing techniques were employed to dislodge and collect the protozoan and helminth parasites from the fish surface. For endoparasites, organs or tissues suspect to harbor parasites were carefully excised and processed

5. Parasite Fixation and Preservation:

The collect protozoan and helminth parasites are preserve using appropriate fixation techniques. Ectoparasites are fixe in suitable fixatives, such as formalin or ethanol. Endoparasites are carefully will remove from the fish tissues and preserve in containers with fixative solution.

6. Microscopic Examination:

Preserve protozoan and helminth parasites are subject to microscopic examination for detail morphological analysis. Slides will prepare using appropriate mounting techniques, and the specimens will observe under a compound microscope. Morphological characteristics will record, including size, shape, color, and any distinct features that aided in parasite identification.

7. Identification of Parasites:

Protozoan and helminth Parasites will identifies using taxonomic keys, reference materials, and expert consultation. Morphological characteristics observe under the microscope will compared with existing literature and identification guides specific to

fish parasites. Molecular techniques, such as DNA sequencing, may have been employed for difficult-to-identify specimens.

8. Data Analysis:

The identifies protozoan and helminth parasites will quantifies in terms of prevalence (percentage of fish infected), mean intensity (average number of parasites per infected fish), and mean abundance (average number of parasites per all fish examined). Statistical analyses, such as chi-square tests or ANOVA, may will be performed to assess differences in parasite prevalence and intensity among fish species or sampling sites.

Study Area: Godavari Basin (Nanded)

5. Importance of study:

• International Status:-

Numerous studies have been conducted worldwide on the prevalence and distribution of the helminth parasite and protozoa fauna in freshwater fishes. Worldwide, helminth parasites and protozoa drastically reduce fish populations. if people eat such contaminated, undercooked fish. It results in a world with a high death rate Faruk, M. A. R. (2018). .

According to estimates from the World Health Organization (WHO), there are now an estimated number of persons afflicted with helminth and fish-borne protozoa. For the locals, fish is an important part of their food. An important group of pathogens that cause infections and disorders in fish in both freshwater and marine habitats are protozoa and helminths. Their significance is directly tied to the possibility that fish infections could have an impact on public health Jyrwa, D. B et al. (2018)

• National status:-

A major part of the Indian economy is the fishing industry. India is ranked second globally in inland fish production, while it is ranked third globally in terms of fish producing nations. Fish illnesses brought on by a range of fish parasites are a constant threat to fish output.

Because they reduce fish's ability to reproduce, marketability, and nutritional value, fish parasites and associated diseases are a serious concern. Due to the weak host-parasite relationship, infection with these parasites can cause poor growth, delay fish sexual maturity and mortality, and cause infections in humans and animals Faruk, M. A. R. (2018). In India, parasitic infections account for 78% of all infections and are more common than microbiological infections; But there is a wide range in the severity of these diseases and the losses they cause. The diversity of India's helminth fauna has been investigated by a number of workers from various regions of the nation. It is anticipated that a solid taxonomic foundation will be necessary

for the application of treatment approaches to eradicate these infections Lightowlers, M. W et al. (2021).

- **Regional Status:-**

The protozoa and helminth parasites of freshwater fish of Indian region ranks amongst the best characterized protozoa and helminth parasites in World. During the past decade our knowledge of protozoa and helminth parasites of freshwater fishes has increased dramatically. Knowledge of particular fish host Donald B. Jyrwa et al. (2016).

Determines identification of parasite with marked host and tissue specificity. Freshwater fishes are good sources of proteins. Several peoples consume fishes because of nutritional value but protozoa and helminth affects the health of fishes and if we consume such kind of infected fishes causes diseases. The present study will be able to increase understanding about studies on protozoan And helminth parasites of freshwater fishes of Godavari Basin (Nanded), which help to adopt control strategies against such infections Salgado-Maldonado et al. (2016).

- **Scope of Study:-**

Fish output is limited by parasitic infections due to the higher fish density in bodies of water where fish pathogens can spread quickly from one fish to another.
Fish farmers may suffer significant financial losses as a result of these infections' potential to kill fish in cases where the entire fish population becomes affected Blasco-Costa et al. (2022). Because certain protozoa and helminth parasites can only be transmitted through fish, fish parasites have a direct or indirect impact on human and domestic animal health. To offer an exhaustive documentation of expertise, this study is aimed to studies on protozoan and helminth parasites of freshwater fishes of Godavari Basin (Nanded) Ziarati, M et al. (2022).

6. Proposed work Plan with a Tentative chapter scheme

1. Introduction
2. Review of Literature
3. Geographical Background of Research Area Godavari Basin (Nanded)
4. Materials and Methods
5. Result & Discussion
   a) Taxonomy of Protozoan and Helminth Parasites.
   b) Characterize the Morphological Features of the Protozoan and Helminth Parasites.
   a) Impact protozoan and helminth parasites on the health and population dynamics of freshwater fishes.
6. Summary & Conclusion.
7. Bibliography.

7. Proposed work Plan/ Formulation and Structure of Study:

First Year: - Review of Literature, Referencing, Research methodology, visit to various localities of Godavari Basin (Nanded) for collection of protozoa and helminth parasites of freshwater fishes. Recording the obtained data for Population dynamics study. Collection and preservation of protozoa and helminth parasites.

Second Year: - Collection of protozoans and helminths of freshwater fish species from Godavari Basin (Nanded). Fixation, preservation, dehydration, staining and whole mount preparation of helminth parasites. To record the obtained data for population dynamics study. Data analysis.

Third Year: - Collection, preservation, staining, mounting and identification of protozoa's and helminths. To record the obtained data for population dynamics study. Data analysis.

Fourth Year: - Confirmation and finalization of obtained data for Biosystematics studies. Camera Lucida line drawings, morphometry, photomicrography, data analysis, drafting, typing and submission of thesis**.**

8. Expected Outcome:

Infections with protozoa and helminths have a detrimental effect on animal health and productivity, which includes freshwater fish. Following the conclusion of this research, it will help to know the Protozoan and Helminth Parasites of Freshwater Fishes of Godavari Basin India. The baseline data will be useful in the successful development and use of an efficient control strategy.

9. References:

1. Tocher, D. R. (2010). Fatty acid requirements in ontogeny of marine and freshwater fish. Aquaculture research, 41(5), 717-732.
2. Vankara, A. P., Mani, G., & Vijayalakshmi, C. (2011). Metazoan parasite infracommunities of the freshwater eel, Mastacembelus armatus Lacèpede, 1800 from River Godavari, India. International Journal of Zoological Research, 7(1), 19.
3. Parker, M., Allen, T., Pearson, G., Peach, N., Flynn, R., & Rees, N. (2012). Border parasites: schistosomiasis control among Uganda's fisherfolk. Journal of Eastern African Studies, 6(1), 98-123.
4. Chalamaiah, M., Hemalatha, R., & Jyothirmayi, T. (2012). Fish protein hydrolysates: proximate composition, amino acid composition, antioxidant activities and applications: a review. Food chemistry, 135(4), 3020-3038.
5. Blasco-Costa, I., Koehler, A. V., Martin, A., & Poulin, R. (2013). Upstream-downstream gradient in infection levels by fish parasites: a common river pattern?. Parasitology, 140(2), 266-274.
6. Ghaly, A. E., Ramakrishnan, V. V., Brooks, M. S., Budge, S. M., & Dave, D. (2013). Fish processing wastes as a potential source of proteins. Amino acids and oils: A critical review. J. Microb. Biochem. Technol, 5(4), 107-129.
7. Tacon, A. G., & Metian, M. (2013). Fish matters: importance of aquatic foods in human nutrition and global food supply. Reviews in fisheries Science, 21(1), 22-38.
8. Kaur, H. (2014). Myxozoan infestation in freshwater fishes in wetlands and aquaculture in Punjab (India). Adv. Anim. Vet. Sci, 2(9), 488-502.
9. Khedkar, G. D., Lutzky, S., Rathod, S., Kalyankar, A., & David, L. (2014). A dual role of dams in fragmentation and support of fish diversity across the Godavari River basin in India. Ecohydrology, 7(6), 1560-1573.
10. Tomáš Scholz et al. (2014). Parasites of Freshwater Fishes In North America: Why So Neglected? Journal of Parasitology, 100(1):26-45. 2014.
11. Béné, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G. I., & Williams, M. (2015). Feeding 9 billion by 2050–Putting fish back on the menu. Food Security, 7, 261-274.
12. Hou, Y., Yin, Y., & Wu, G. (2015). Dietary essentiality of "nutritionally non-essential amino acids" for animals and humans. Experimental Biology and Medicine, 240(8), 997-1007.
13. Macadam, C. R., & Stockan, J. A. (2015). More than just fish food: ecosystem services provided by freshwater insects. Ecological Entomology, 40, 113-123.
14. Brunner, F. S., & Eizaguirre, C. (2016). Can environmental change affect host/parasite-mediated speciation? Zoology, 119(4), 384-394.

15. Donald B. Jyrwa et al. (2016). Helminth parasite spectrum of fishes in Meghalaya, Northeast India: a checklist. Journal of Parasitic Diseases. Volume 40, pages 312–329, (2016)
16. Jyrwa, D. B., Thapa, S., & Tandon, V. (2016). Helminth parasite spectrum of fishes in Meghalaya, Northeast India: a checklist. Journal of Parasitic Diseases, 40, 312-329.
17. KS, R. T. S. V. A., Bhat, S. P., & Rahaman, M. F. (2016). Recurring fish mortality episodes in Bangalore lakes: sign of irresponsible and fragmented governance. Energy.
18. Pink, R. M. (2016). Water Rights in Southeast Asia and India (pp. 1-14). New York, NY, USA: Palgrave Macmillan.
19. Salgado-Maldonado, G., Novelo-Turcotte, M. T., Caspeta-Mandujano, J. M., Vazquez-Hurtado, G., Quiroz-Martínez, B., Mercado-Silva, N., & Favila, M. (2016). Host specificity and the structure of helminth parasite communities of fishes in a Neotropical river in Mexico. Parasite, 23.
20. Taqdees Farooq et al. 2016. Endoparasites of some economically important food fishes of River Jhelum, Kashmir (India), Journal of Parasitic Diseases. 40, pages860–871 (2016).
21. Paladini, G., Longshaw, M., Gustinelli, A., & Shinn, A. P. (2017). Parasitic diseases in aquaculture: their biology, diagnosis and control. Diagnosis and control of diseases of fish and shellfish, 37-107.
22. Prabu, E., Felix, S., Felix, N., Ahilan, B., & Ruby, P. (2017). An overview on significance of fish nutrition in aquaculture industry. International Journal of Fisheries and Aquatic Studies, 5(6), 349-355
23. Younis, A. E., Saad, A. I., & Rabei, J. M. (2017). The occurrence of Contracaecum sp. larvae (Nematoda: Anisakidae) in four teleostean species from Lake Nasser, Egypt: morphological and molecular studies. The Journal of Basic and Applied Zoology, 78, 1-13.
24. Gasco, L., Gai, F., Maricchiolo, G., Genovese, L., Ragonese, S., Bottari, T., ... & Caruso, G. (2018). Supplementation of vitamins, minerals, enzymes and antioxidants in fish feeds. Feeds for the Aquaculture Sector: Current Situation and Alternative Sources, 63-103.
25. Faruk, M. A. R. (2018). Fish parasite: infectious diseases associated with fish parasite. In Seafood Safety and Quality (pp. 154-176). CRC Press.
26. Khalili Tilami, S., & Sampels, S. (2018). Nutritional value of fish: lipids, proteins, vitamins, and minerals. Reviews in Fisheries Science & Aquaculture, 26(2), 243-253.
27. Maciel, P. O., Garcia, F., Chagas, E. C., Fujimoto, R. Y., & Tavares-Dias, M. (2018). Trichodinidae in commercial fish in South America. Reviews in Fish Biology and Fisheries, 28, 33-56
28. Paul, B. N., Bhowmick, S., Chanda, S., Sridhar, N., & Giri, S. S. (2018). Nutrient profile of five freshwater fish species. SAARC Journal of Agriculture, 16(2), 25-41.

29. Pelletier, N., Klinger, D. H., Sims, N. A., Yoshioka, J. R., & Kittinger, J. N. (2018). Nutritional attributes, substitutability, scalability, and environmental intensity of an illustrative subset of current and future protein sources for aquaculture feeds: joint consideration of potential synergies and trade-offs. Environmental science & technology, 52(10), 5532-5544.
30. Balami, S., Sharma, A., & Karn, R. (2019). Significance of nutritional value of fish for human health. Malaysian Journal of Halal Research, 2(2), 32-34.
31. Sarojnalini, C., & Hei, A. (2019). Fish as an important functional food for quality life. U: Functional Foods, (Lagouri, V, Ured), 2019, 77-97.
32. Aline A. Acosta et al. 2020. Diversity of helminth parasites of eight siluriform fishes from the Aguapeí River, upper Paraná basin, São Paulo state, Brazil. IJP: Parasites and Wildlife 11 (2020) 120–128.
33. Hei, A. (2020, January). Fish as a Functional Food in Human Health, Diseases and Well–Being. In Proceedings of the 107th Indian Science Congress, Banglore, India (pp. 3-7).
34. Lees, M. J., & Carson, B. P. (2020). The potential role of fish-derived protein hydrolysates on metabolic health, skeletal muscle mass and function in ageing. Nutrients, 12(8), 2434.
35. Malik, D. S., Sharma, A. K., Sharma, A. K., Thakur, R., & Sharma, M. (2020). A review on impact of water pollution on freshwater fish species and their aquatic environment. Advances in environmental pollution management: wastewater impacts and treatment technologies, 1, 10-28.
36. Muhammad Moosa Abro et al, 2020. Detection of a pathogenic nematode from tire track eel, Mastacembelus armatus captured in the Indus River, Sindh, Pakistan, Pure and Applied Biology. Vol. 9, Issue 1, pp91-95.
37. Lall, S. P., & Kaushik, S. J. (2021). Nutrition and metabolism of minerals in fish. Animals, 11(09), 2711.
38. Lightowlers, M. W., Gasser, R. B., Hemphill, A., Romig, T., Tamarozzi, F., Deplazes, P., ... & Kern, P. (2021). Advances in the treatment, diagnosis, control and scientific understanding of taeniid cestode parasite infections over the past 50 years. International journal for parasitology, 51(13-14), 1167-1192.
39. Buchmann, K. (2022). Control of parasitic diseases in aquaculture. Parasitology, 149(14), 1985-1997.
40. Overstreet, R. M. (2021). Parasitic diseases of fishes and their relationship with toxicants and other environmental factors. In Pathobiology of marine and estuarine organisms (pp. 111-156). CRC press.
41. Chen, J., Jayachandran, M., Bai, W., & Xu, B. (2022). A critical review on the health benefits of fish consumption and its bioactive constituents. Food Chemistry, 369, 130874.

42. Heino, J., & Koljonen, S. (2022). A roadmap for sustaining biodiversity and ecosystem services through joint conservation and restoration of northern drainage basins. Ecological Solutions and Evidence, 3(2), e12142.
43. Mina Ziarati. 2022, Zoonotic diseases of fish and their prevention and control National Library of Medicine National Center for Biotechnology Information. Veterinary Quarterly 2022, VOL. 42, NO. 1, 95–118
44. Vanhove, M. P., Kmentová, N., Luus-Powell, W. J., Netherlands, E. C., de Buron, I., & Barger, M. A. (2022). A snapshot of parasites in tropical and subtropical freshwater wetlands: modest attention for major players. In Fundamentals of Tropical Freshwater Wetlands (pp. 417-485). Elsevier
45. Ziarati, M., Zorriehzahra, M. J., Hassantabar, F., Mehrabi, Z., Dhawan, M., Sharun, K., ... & Shamsi, S. (2022). Zoonotic diseases of fish and their prevention and control. Veterinary Quarterly, 42(1), 95-118.
46. Lutz, W. (2023). Population decline will likely become a global trend and benefit long-term human wellbeing. Vienna Yearbook of Population Research, 21.
47. Nair, N. V., & Nayak, P. K. (2023). Uncovering water quality and evaluating vulnerabilities of small-scale fisheries in Chilika Lagoon, India. Frontiers in Marine Science.
48. Panda, B. P., Mohanta, Y. K., Parida, S. P., Pradhan, A., Mohanta, T. K., Patowary, K., ... & Sarma, H. (2023). Metal pollution in freshwater fish: A key indicator of contamination and carcinogenic risk to public health. Environmental Pollution, 330, 121796.
49. Salwa Mahmoud Abd-ELrahman et al.2023. Prevalence and Morphological Investigation of Parasitic Infection in Freshwater Fish (Nile Tilapia) from Upper Egypt, Animals 2023, 13, 1088. https://doi.org/10.3390/ani13061088.
50. El-Khayat, H. M., Sayed, S. S., Mohammed, W. A., & Sadek, A. S. M. (2024). Protozoan and helminths infestation of Nile tilapia Oreochromis niloticus and its correlation with certain water quality variables along river Nile in the area of Greater Cairo. Environmental Pollution, 123459.

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